

# Food Hydrocolloids

## Volume I

Editor

**Martin Glicksman**  
General Foods Corporation  
Tarrytown, New York

**BEST AVAILABLE COPY**



CRC Press, Inc.  
Boca Raton, Florida

1982

is  
al  
c-  
id  
al  
v-  
n  
v  
e  
l  
.l

Library of Congress Cataloging in Publication Data

Main entry under title:

Food hydrocolloids

Bibliography: v. 1, p.

Includes index.

1. Colloids. I. Glicksman, Martin.

TR453.C65F67 664'.01 81-10018

ISBN 0-8493-6041-2 (v. 1) AACR2

This book represents information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. A wide variety of references are listed. Every reasonable effort has been made to give reliable data and information, but the author and the publisher cannot assume responsibility for the validity of all materials or for the consequences of their use.

All rights reserved. This book, or any parts thereof, may not be reproduced in any form without written consent from the publisher.

Direct all inquiries to CRC Press, Inc., 2000 N.W. 24th Street, Boca Raton, Florida 33431.

© 1982 by CRC Press, Inc.

International Standard Book Number 0-8493-6041-2

Library of Congress Card Number 81-10018  
Printed in the United States

- Spray-dried emulsions, 79—80
- Spray-dried powders, 86
- Spreads, 53—54, 79, 144—145, 154, 172
- Stability, stabilizing properties, and stabilizing applications
  - emulsions, 78—81, 137—138, 145—146, 183
  - fermentation gums, 130—131, 133, 136—139, 142—143, 145—146, 153—154, 162—163, 171—172, 174, 176, 178, 180, 183, 185, 189, 192, 195
  - foams, 7, 49, 82—84, 162, 183
  - microbial, see Microbial stability
  - natural gums, 7, 9, 12—13, 41—42, 45, 49, 78—85
  - suspensions and dispersions, 84—85, 137—138
  - thermal, see Thermal stability
- Standards, see Regulation
- Starch, see also specific types by name, 131, 169, 176—178, 180—182
  - browning reaction, 41
  - derivatives, 110
  - dextran related to, 158—159
  - functional properties, 20, 60, 66, 78, 85, 90, 153, 182
  - hydrolysis, 181—182
  - hydrolyzed, 181—182, 185
  - modified, 5, 90, 107—108, 110, 143—144
  - nutritional and physiological value, 107—110, 176
  - origins, classification, and structure, 5, 10—11, 13, 23, 29—30
  - oxidized, 107, 109—110
  - soluble, 180—181
  - xanthan complexes, 143—144, 146
- Starch amylose, 8, 71, 90
- Starch amylose films, 90
- Starch hydrolysate, 41
- Starch-like polymer, 169
- Starch syrup, 41
- Starchy jelly, 154
- Static foam, 83
- Stereochemistry, carbohydrates, 20
- Stereogeometry, multiple group, 21, 27
- Stereoisomer, 22
- Stickiness, see Adhesive qualities
- Stomach-irritant preventive, 163
- Strength, gel, 72—75, 139, 141, 152—153, 196—197
- Stress, shear, effects of, see Shear parameters
- Strip agar, 41
- Stromatinia* sp., 172
- Structural polysaccharides, 125
- Structure, see also subhead "origins, classification, and structure" beneath specific gums by name
  - branched, 8—11, 25—27, 29
  - branch-on-branch, 8—9
  - bush-like, 8—9
  - carbohydrate hydrocolloids, 19—44
  - crystal, control of, 91
  - dietary fiber, 75—76
  - double helix, 34, 37, 69
  - fermentation gums, 32, 34—35, 131—134, 138—139, 152—153, 158, 161—162, 170—171, 173, 177—180, 183—185, 188, 193—194
  - functional properties and, 6—11, 138—139
  - hairy regions, see Hairy regions
  - linear, 8—10
  - natural gums, 6—11, 19—44, 70—71, 75—76, 91
  - randomness, 28—30
  - smooth regions, see Smooth regions
  - types, 7—11
- Substituted linear polysaccharide, 8—9
- Succinoglucan, 152
- Sucrose, 23, 131, 159—160, 163, 169, 177, 183, 185
- Sucrose-containing beverages and foods, 158
- Sugar, see also specific types by name, 39—44, 158—160, 162, 170, 194—195
  - browning, nonenzymic, 39—42
  - derivatives, 22—23
  - dextran contamination, 158
  - digestibility and digestion, 102—104
  - function, 20
  - gelation affected by, 72
  - halogenated, 22
  - moisture content, 43
  - origins, classification, and structure, 5, 8—10, 20—29
  - terminology, 20—25
  - water activity controlled by, 42—44
- Sugar syrup, 7, 49, 51—52, 158, 162—163
- Sulfite, 40—41
- Suppression, microorganisms, 42, 44, 85
- Surface tension, reduction of, 80, 82, 84
- Surfactants, 80, 85
- Suspensions and dispersions, 7, 49, 51—53, 78—79, 163, 171—172, 174—176, 183
  - definition, 84
  - dilute colloidal dispersions, 51—52
  - food applications, 83—85, 142
  - permanent suspensions, 84
  - stabilizing, 84—85, 137—138
  - viscosity, 84
- Sustained-release medications, 86, 90, 163
- Sweetness, 42
- Sweet potato starch, 109
- Swelling agents, 7, 49
- Syneresis, 39, 69, 153, 171, 175
  - inhibitors of, 7, 49, 142, 145
- Synergism and synergistic effects, 32, 64, 92, 139—142, 174
- Synthetic cream, see Coffee whiteners
- Synthetic gums, see also specific types by name, 4—5, 12, 102
- Synthesis
  - bio-, see Biosynthesis; Fermentation
  - chemical, see Chemical synthesis
- Syrup, 7, 41, 43, 49, 51—54, 60, 84—85, 93, 130, 154, 158, 162—163, 195

Table 1 (continued)  
 BIOUTILIZATION OF HYDROCOLLOIDS

| Substance                                     | Apparent digestibility % | Available calories kcal/g | Comments   |
|---|--------------------------|---------------------------|--|
| Fermentation gums                             |                          |                           |  |
| Dextran                                       | 78, 90, 86 (48)          | 4*, 4*, 2.6* (48)         | Large molecular compounds have no blood sugar effect (73); rise in blood sugar (71, 72); glycogenic (71) |
| Xanthan                                       | 0 (76, 48)               | 0.5 (76)                  | Does not support growth (48)   |
| Modified natural                              |                          |                           |  |
| Cellulose derivatives                         |                          |                           |  |
| Carboxymethylcellulose                        | 10 (57)                  | 0.5* (57)                 | No metabolism of a radiolabel (57)   |
| Methylcellulose                               | 10 (57)                  | 0.5* (57)                 |  |
| Methylethylcellulose                          | 10 (57)                  | 0.5* (57)                 |  |
| Hydroxypropylmethyl cellulose                 | 10 (57)                  | 0* (81)                   | Biochemically inert (57)   |
| Hydroxypropylcellulose                        | 3 or less (57)           | 0* (57)                   |  |
| Starch derivatives                            |                          |                           |  |
| Corn starch oxidized (6%, Cl <sub>2</sub> )   | 100 (82)                 | 4* (82)                   | Low nutritional value (82)   |
| Corn starch oxidized (43.2% Cl <sub>2</sub> ) | very low (82)            |                           |  |
| Corn starch phosphate (0.5 to 0.9 DS)         | 100 (82)                 | 4* (82)                   |  |
| Hydroxyethyl corn starch                      | 100 (81)                 | 4* (57)                   |  |
| Acetylated distarch adipate                   | 755 (57)                 | 4* (57)                   |  |
| Hydroxypropyl starch (0.141 DS)               |                          | 2.44 (53)                 |  |
| (0.138 DS)                                    |                          | 2.32 (53)                 |  |
| (0.032 DS)                                    |                          | 3.08 (53)                 |  |

\* Calories estimated from data available in cited references

biological value. Pectin fed at graded levels of 0 to 20% of a purified rat diet containing either 22% or 8.5% casein causes progressively greater depressions of protein digestion at both protein levels.<sup>41</sup> Pectin at 5% and 10% of the diet remaining unabsorbed in the studies of Viola et al. reduces protein absorption.<sup>42</sup> Algin in these same studies only slightly impairs protein absorption.<sup>42</sup> With increasing levels of psyllium, Kies and Fox find nitrogen balance in the rat deteriorates.<sup>92</sup> Studies with mice at dietary levels of 0 to 20% psyllium result in an inconsistent effect on PER and nitrogen balance but apparent digestibility and utilization decreases with increasing hemicellulose level.<sup>93</sup> The inclusion of ispaghula in the diet of humans, 25 g/day for three weeks does not result in an increased nitrogen excretion.<sup>87</sup>

The animal studies indicate that gums may cause a rise in fecal nitrogen excretion. Bacterial activity may be enhanced by the presence of fermentable polysaccharide in the colon. The nitrogen needed for enhanced bacterial activity can come from dietary protein or host protein. If the nitrogen comes from host protein, urinary nitrogen would be reduced. If there are increased fecal losses of nitrogen, this comes from microbial protein or the products of microbial activity.

#### B. Fat

Total fat excretion and a significantly greater percent fat excretion is observed on psyllium containing diets in mice.<sup>93</sup> In man 15 g of pectin added to meals increased

manufacture, 152  
 origin, classification, and structure, 5, 125, 152  
 pH effects, 152—153  
 regulatory status, 152—153  
 texture, 153—155  
 viscosity, 152  
 Custard, 154  
 CVD, see Cardiovascular disease

## D

D, prefix explained, 20  
 Dairy desserts, see also specific products by  
   name, 79—80  
 Dairy drinks, 172  
 Dairy products, see also Milk and milk products;  
   specific products by name, 130, 143—145,  
   172  
 Dairy substitutes, 145  
 Damar, 4  
 Deacylated PS-60, 193—197  
 Deacylated xanthan, 131  
 Debittering, yeast, 170  
 Definitions, see Terminology (definitions)  
 Degradation  
   enzymatic, see Enzymatic degradation  
   microbial, see Microbial degradation  
 Degraded gum arabic, 31—32  
 Dehydrated foods, 92, 163  
 Delaney clause, 14—15  
 Delayed Release Medications, see also Sustained-  
   Release Medications, 163  
 Derivatives  
   cellulose, 5  
   dextran, 162—163  
   starch 110  
   sugar, 22—23  
   xanthan, 131  
 Dessert gels, 54, 65, 92—93, 154—155, 172  
 Desserts, see also specific types by name, 7, 49,  
   54, 65—66, 79—81, 143—144, 154—155  
 Dextran  
   commercialization, 159—160  
   complexes, 162—163  
   conformation, 162  
   definition, 158, 160, 162  
   derivatives, 162—163  
   food applications, 162—163  
   functional properties, 54, 159—163  
   manufacture, 159—161  
   metabolism, 162  
   molecular weight, 159—163  
   nutritional and physiological value, 106, 110,  
     159—160, 162—163, 179  
   origins, classification, and structure, 5, 8, 27,  
     125, 157—162  
   pharmaceutical applications, 159—160, 163, 179  
   regulatory status, 160  
   starch related to, 158—159  
   sugar contamination by, 158  
   toxicity, 163  
   viscosity, 158, 161—163  
 Dextranase, 106

Dextran phosphate, 163  
 Dextran-producing microorganisms, 158—160  
 Dextransucrase, 160, 163  
 Dextran sulfate, 163  
 Dextran syrup, 163  
 Dextrin, 137, 146, 158  
 Dextrose-alginate films, 85  
 Diabetes, 76—78, 112—114  
 Diabetic foods, 154  
 Dialdehyde dextran, 163  
 Diarrhea, 105, 107—109, 112  
 Diastereoisomer, 21  
 Diastereomer, 21  
 Dietary fiber, 7, 49, 74—78  
   antitoxic properties, 114—115  
   cellulose, 75—76, 78, 114  
   cereal, 78, 112  
   crude, 75, 103  
   definition, 74—76  
   fermentation gums, 154—155  
   nutritional and physiological value, 102—103,  
     112—115  
   protein, 155  
   structure and components, 75—76  
   therapeutic applications, 76—78, 112—115  
   viscosity, 77  
 Dietetic applications, see also specific products by  
   name, 7, 49, 146, 152, 154, 162, 172, 182  
 Differential Scanning Calorimeter, 43  
 Digestibility and digestion, nutrients and gums,  
   102—112, 129, 181  
   microbial degradation, 103—104, 110  
   study methods, 103  
 Digoxin, 113  
 Dilatancy, 52—54, 56, 58  
 Dilute colloidal dispersions, 51—52  
 Dips, chip, 172  
 Dispersions, see Suspensions and dispersions  
 Dissaccharides, 22  
 Distemper, 4  
 Divalent salts, effects of, 136  
 Diverticular disease, 112  
 Divinity candy, 145  
 Double helix, structure and, 34, 37, 69, 131, 134,  
   142  
 Dough, 145, 162  
 Doughnuts, 86, 142, 146  
 Drainage, foam, 84  
 Dressing, salad, see Salad dressing  
 Dried fruit, 43, 163  
 Dried fruit powders, 84  
 Dried meat products, 178  
 Dried soup, 89  
 Drying behavior, foams, 84  
 Dry mix products, 89, 92, 142—143, 146, 154,  
   195  
 Dyes, 153, 185  
 Dynamic foam, 83

## E

Edible packaging, see also Soluble packaging, 90,  
 154

The shape of B-512 dextran in solution is thought to be compact, but shaggy helical coils<sup>40</sup> and many of the properties of dextran solutions can be explained by the presence of molecular associations of helical structures.<sup>41</sup> Treatment with acid or other methods which irreversibly destroy the helix, improves the solubility of dextran.

## VI. PROPERTIES

Dextran is a fine, white powder that dissolves readily in hot or cold water to give clear, viscous solutions. It has a comparatively low viscosity and can form solutions of up to 50% concentrations. It is tasteless, odorless, and since it is a neutral polysaccharide it is chemically inert and compatible with most food ingredients. Due to its low degree of structural branching it shows a high resistance to hydrolytic depolymerization.

Dextran has effective emulsifying and stabilizing properties in oil-in-water emulsion systems. It has good humectant and water-holding properties and imparts good bodying attributes to liquid systems.

Feeding tests on animals and humans have shown that dextran is completely but slowly metabolized.<sup>42,43</sup> Baker<sup>20</sup> reported that biological tests demonstrated that when dextran containing a high proportion of  $\alpha$ -(1 $\rightarrow$ 6) linkages is included in a normal diet on a regular regimen, gain in body weight is inhibited. Even though dextran is edible and assimilated without unfavorable effect on the human system, it appears that the  $\alpha$ -(1 $\rightarrow$ 6) linkages are resistant to attack by bacteria and enzymes present in the gastrointestinal tract. This suggested its use in low-calorie foods and in reducing diets.

## VII. APPLICATIONS

### A. Foods

Many food applications of dextrans have been proposed and reported in the literature but none are believed to be in use today.<sup>13,44</sup> In varied food applications, dextran was reported to have very useful and exploitable functional properties. Dextran improved moisture retention and inhibited sugar crystallization in syrups and confections,<sup>45,100</sup> acted as a gelling agent in jelly candies and gum drops,<sup>46,101</sup> prevented shrinkage and ice crystal formation in ice cream,<sup>47</sup> functioned as a stabilizer in bakery icings,<sup>48</sup> and served as a bodying agent in pudding preparations.<sup>49</sup> Derivatives such as carboxymethyldextran functioned effectively as a stabilizer for ice cream<sup>50</sup> and a thickening or bodying agent for fruit syrups.<sup>51</sup> These applications, among others, were described in a number of patents but are not believed to have made much impact in the food industry.

Bohn<sup>52</sup> found that the incorporation of small quantities (0.01-10% of flour used) of dextran in yeast-raised bread doughs containing both yeast and gluten, produced breads that were softer and had a greater volume and longer shelf life than ordinary bread. The dextrans preferred were derived from *Leuconostoc mesenteroides* and had molecular weights of about 20 million to 40 million. Toulmin<sup>53</sup> mixed dextran with sugar, milk, water, or oily plasticizer to give a mash that could be molded and baked to make ice cream cones. Hamburg<sup>54</sup> replaced 10 to 20% of the malt with dextran in the production of Pilsner beer. The dextran beers were reported to have good flavor and foam stability and the same color as pure malt beer. Carboxymethyldextran, when added to beer and other fermented malt beverages at about 0.5% concentrations, functioned as an effective foam stabilizer.<sup>55</sup>

Dextran was reported effective as a stabilizer for chocolate milk beverages<sup>56</sup> and for soft drinks and flavor extracts.<sup>57</sup> Hughes<sup>58</sup> found it to be useful in the production of noncrystallizing sugar syrups where stability and viscosity were important qualities. Dextran has also been suggested for use as a bodying agent in low-calorie, sugar-free beverages.<sup>59</sup>

Mahoney<sup>57</sup> described dextran as a desirable constituent for sugar-based products like candies, fondants, jellies, and canned fruits. It prevented crystallization, improved moisture retention, improved body, and maintained flavor and appearance. Wadsworth and Hughes<sup>58</sup> subsequently combined the entire sterile culture liquor of dextran with a sucrose syrup to prepare a noncrystallizing sugar syrup of exceptionally high viscosity. Corman et al.<sup>59</sup> used purified dextranase to convert a sucrose solution enzymatically to a higher viscosity, fruit additive, dextran syrup, containing all the D-fructose originally present in the sucrose molecule. Toulmin<sup>60</sup> reported its use as a gelling agent for gum and jelly confections. Morgan et al.<sup>61-63</sup> reported it being used for the preparation of dehydrated foods such as fruit and vegetable juices.

Dextran has been suggested as a preservative coating for many food products such as shrimp, meat, dried fruit, and cheese.<sup>60-62,96</sup> The addition of antibiotics to dextran coatings lengthened the storage life of quick frozen foods such as fish or spinach.<sup>63</sup> Chicken broiler parts were protected against dehydration and skin darkening by covering them in a similar way with a dextran coating.<sup>64</sup>

Dextran was suggested for use as a conditioner in chewing gum, a stabilizer for ice cream products, and a thickener for frostings and synthetic creams.<sup>65</sup> In ice cream it was reported to prevent shrinkage and ice formation.<sup>67</sup> It showed effective functional properties as a bodying agent in pudding compositions<sup>69,103</sup> and as a stabilizing agent in icing compositions.<sup>48,102</sup>

Carboxymethyldextran was reported to be effective as a flavor fixative for encapsulated citrus oil<sup>66</sup> and as a protective coating for monosodium glutamate to inhibit loss of potency.<sup>67</sup>

The incorporation of 0.03 to 0.5% of carboxymethyldextran was said to improve the color and increase the water-binding capacity of meat sausages.<sup>68</sup>

## B. Pharmaceuticals

By far the most important use of dextran has been as a blood plasma extender and this application has received the most attention from researchers. For this purpose a fraction of average molecular weight  $75,000 \pm 25,000$  having rigidly controlled weight distribution and purity is administered intravenously as a 6% solution in physiological saline.<sup>69</sup>

Other pharmaceutical applications reported for dextran include its use as a cryoprotective agent for protecting cells against damage by freezing,<sup>70-72</sup> a suspending agent for X-ray opaque compositions,<sup>73</sup> a stabilizing agent for water-insoluble vitamin preparations,<sup>74</sup> a binder for tableting,<sup>75</sup> a solution retarding agent in sustained-release tablets,<sup>76</sup> a pharmaceutical taste masking agent,<sup>77</sup> a stomach-irritant preventive,<sup>77</sup> and a drug encapsulating agent in combination with methylcellulose.<sup>78</sup>

Some dextran derivatives have also been reported in pharmaceutical applications. Dextran sulfate has been recommended for use in treating simple goiter<sup>79</sup> and peptic ulcers<sup>80</sup> and has been stated to have both anticoagulant and antilipemic properties<sup>81</sup> useful in the treatment of lipemia and arteriosclerosis.<sup>82,83</sup> Dextran phosphate was reported to inhibit peptic activity.<sup>84</sup>

Delayed release or prolonged action medications have been made using benzyl-dextran,<sup>85,86</sup> carboxymethyl-benzyl-dextran,<sup>87</sup> and dialdehyde dextran.<sup>88</sup> Toxicity and irritation of some drugs have been reduced by reacting dextran derivatives with the active ingredient as shown by reacting iodine with dextran to form water-soluble nontoxic iododextran<sup>89</sup> and by reacting isoniazide with dialdehyde dextran to give a low toxicity tuberculostatic compound.<sup>90</sup>

Carboxymethyldextran has been utilized as a carrier for antibiotics and germicides<sup>91</sup> and as an auxiliary binding agent in tablets.<sup>92,93</sup> The whole family of hydroxyalkyl-dextran have been used to make blood plasma extenders with improved storage properties.<sup>94</sup>

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☒ **FADED TEXT OR DRAWING**
- ☒ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**